Abstract

Perovskite oxides have provided a wide variety of exotic functionalities based on their unique physical and chemical properties. By combining different perovskite oxides, interesting physical phenomena have been observed at the interfaces of perovskite heterostructures. The most interesting among these phenomena is the formation of two dimensional electron gas at the interface of two perovskite materials $SrTiO_3$ and $LaAlO_3$ which led to a number of fascinating physical properties such as metal-insulator transition, superconductivity, large negative magnetoresistance and so on. This has raised the interest in exploiting the interface of various hybrids structures built on the perovskite oxide backbone. On the other hand, the two dimensional (2D) van der Waals materials such as graphene, MoS_2, boron nitride etc. represent a new paradigm in the 2D electronics. The functionalities of these individual materials have been combined to obtain new enriched functionalities by stacking different materials together forming van der Waals heterostructures. In this work, we present a detailed study of the interface in hybrid structures made of van der Waals materials (graphene and MoS_2) and their hybrids with a perovskite material namely, $SrTiO_3$ which is known as the building block of complex oxide heterostructures.

In graphene-MoS_2 vertical heterostructure, we have carried out a detailed set of investigations on the modulation of the Schottky barrier at the graphene-MoS_2 interface with varying external electric field. By using different stacking sequences and device structures, we obtained high mobility at large current on-off ratio at room temperature along with a tunable Schottky barrier which can be varied as high as ~ 0.4 eV by applying electric field. We also explored the interface of graphene and $SrTiO_3$ as well as MoS_2 and $SrTiO_3$ by electrical transport and low frequency $1/f$ noise measurements. We observed a hysteretic feature in the transfer characteristics of dual gated graphene and MoS_2 field effect transistors on $SrTiO_3$. The dual gated geometry enabled us to measure the effective capacitance of $SrTiO_3$ interface which showed an enhancement indicating the possible existence of negative capacitance developed by the surface dipoles at the interface of $SrTiO_3$ and the graphene or MoS_2 channel. Our $1/f$ noise study and the analysis of higher order statistics of noise also support the possibility of electric field-driven reorientable surface

dipoles at the interface.